

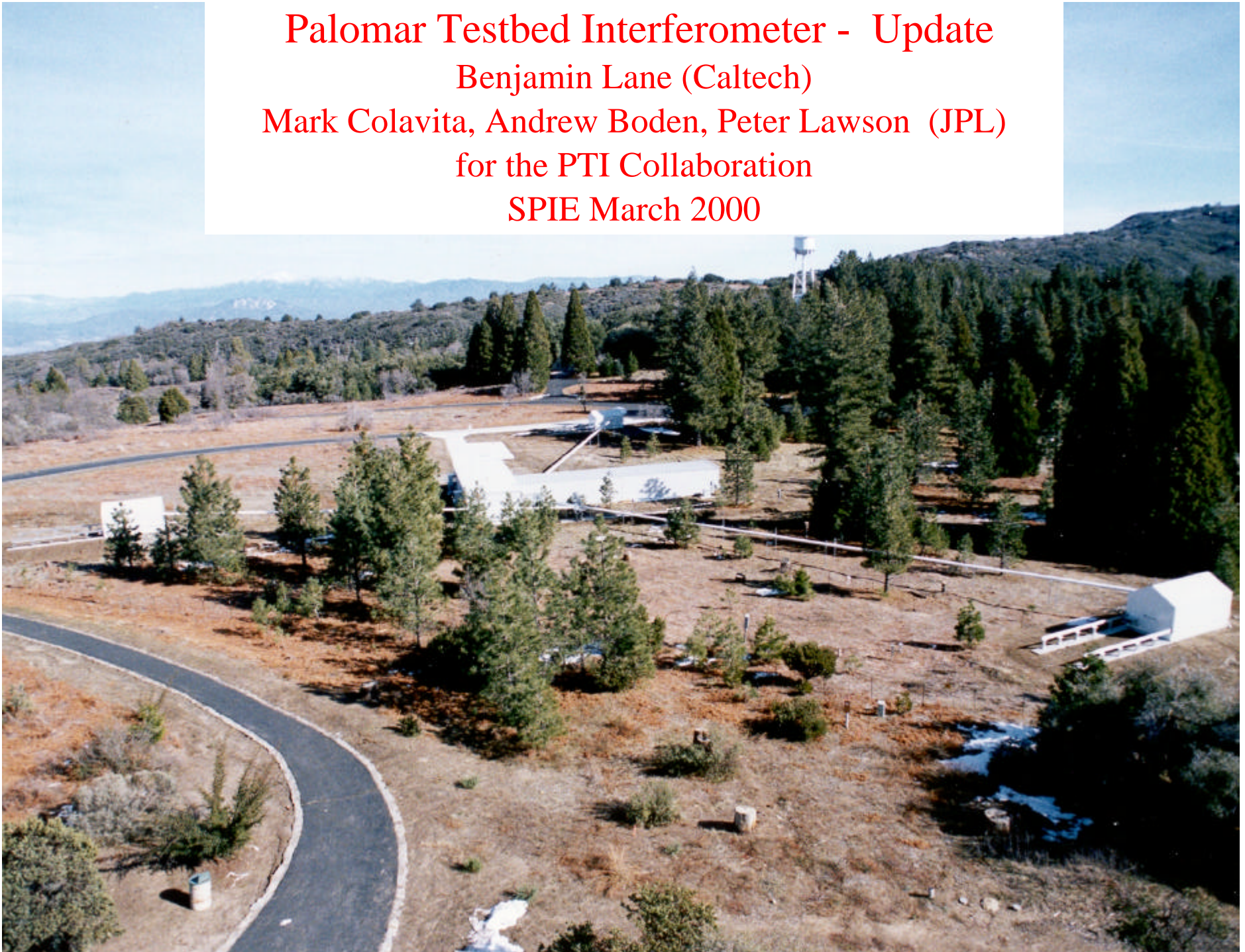
Palomar Testbed Interferometer - Update

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Mark Colavita, Andrew Boden, Peter Lawson (JPL)

for the PTI Collaboration

SPIE March 2000



Members of the PTI Collaboration

Name	Affiliation	Primary PTI Interests
R. L. Akeson	Caltech	Young Stellar Objects Differential Phase
R. Barnbery	JPL	
A. F. Boden	Caltech	Spectroscopic Binaries Astrometry
M. M. Colavita	JPL	Astrometry
M. J. Creech-Eakman	JPL/Caltech	Mira Variable Stars Young Stellar Objects Mid-IR Instruments and Detector Technology
P. J. Dumont	JPL	Astrometry
C. D. Koresko	Caltech	RS CVn Stars
M. Kuchner	Caltech	Cepheid Variables
S. R. Kulkarni	Caltech	Science Program Coordination
B. Lane	Caltech/JPL	Main Sequence Stars Instrumentation
P. Lawson	JPL	Astrometry Instrumentation
R. Linfield	Caltech	Atmospheric Studies
M. Shao	JPL	
M. Swain	JPL	Differential Phase
R.R. Thompson	JPL/University of Wyoming	Evolved Stars Stellar Angular Diameters
G. T. van Belle	JPL	Evolved Stars Stellar Angular Diameters
D. Van Buren	Caltech	
G. Vasisht	JPL	
J. K. Wallace	JPL	Instrumentation
F. P. Wilkin	Caltech/IPAC	Young Stellar Objects Astrometry



Overview

- Introduction to PTI
- The 1999 Observing Season
- Instrument Improvements
- Astrometry
- Phase Referencing
- Software Developments
- Future Plans

Instrument Description

- NASA funded, tech dev. for Keck and other interferometers
- 2-way system, 110 m max baseline
- 40 cm collecting apertures
- Active broadband fringe tracking at K (2-2.4 μm) or H (1.5-1.8 μm)
- Spectrometer resolution of $R = 25 - 50$
- Angle tracking at R + I (0.7 – 1.0 μm)
- Dual-star capability for narrow-angle astrometry

More detail:
ApJ 510, 505 (1999)





Observing Modes

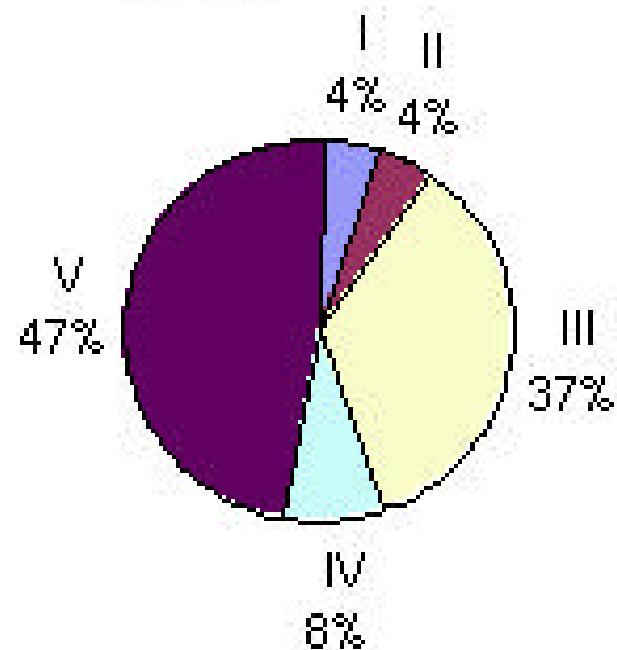
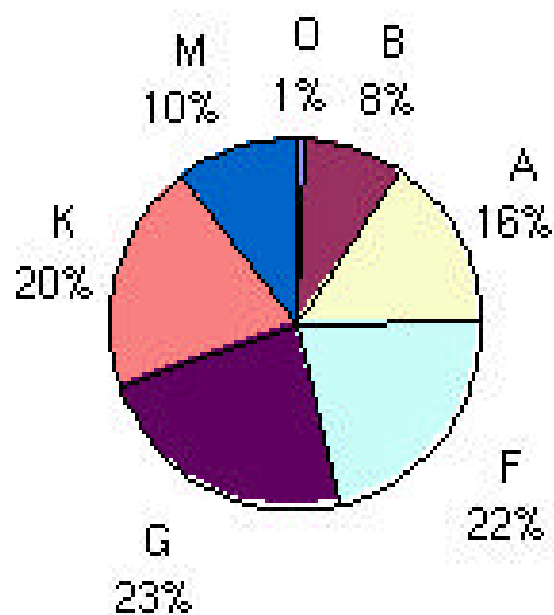
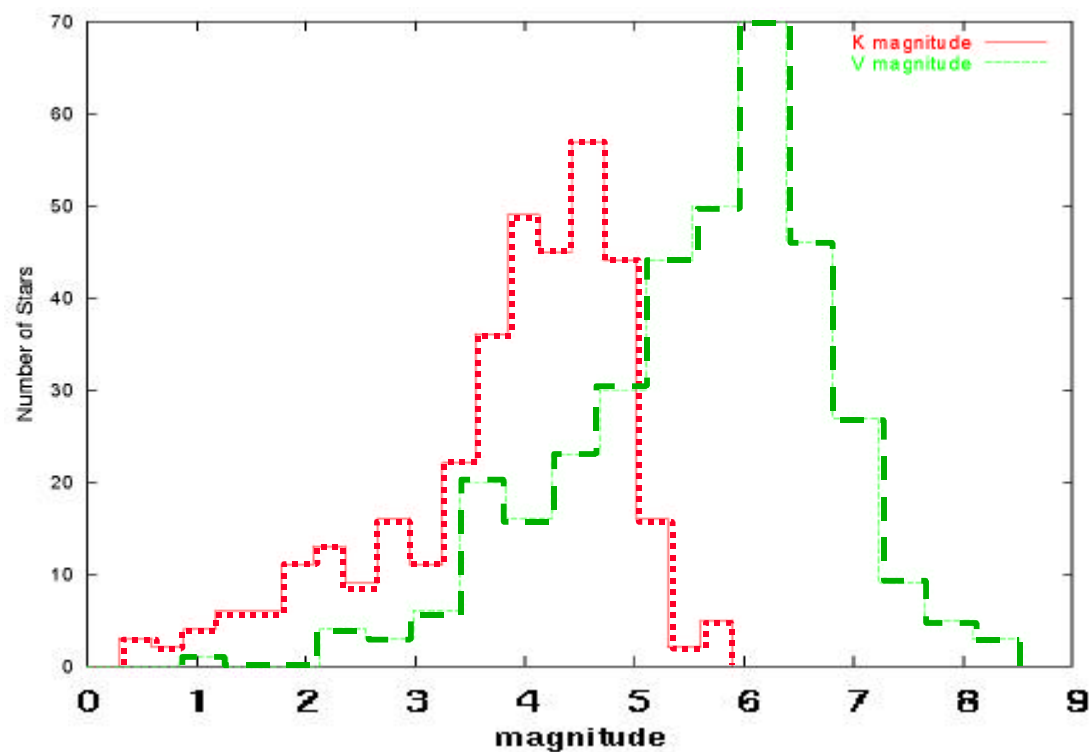
- Single Star Mode
 - » One interferometer, one baseline, visibility measurements
 - » Binary stars, stellar apparent diameters
- Bright Dual-Star Mode
 - » Two interferometers, independent fringe tracking
 - » Astrometry of similar-brightness visual binaries (61 Cygni)
- Faint (or Phase Referenced) Dual-Star Mode
 - » Two interferometers, tracking info from brighter star fed to other fringe tracker
 - » Astrometry with faint reference



Observing Stats 1999

- Up 227 of 291 possible nights
 - » 184 single star
 - » 28 bright dual-star
 - » 15 phase-reference testing
- 9788 scans on 574 separate targets
 - » (1 scan = 130 sec of fringe tracking data + calibrations)
- Highest-throughput night: 122 scans
- Efficiency (fraction time tracking fringe + calibrations): 30%

Observing Stats 1999



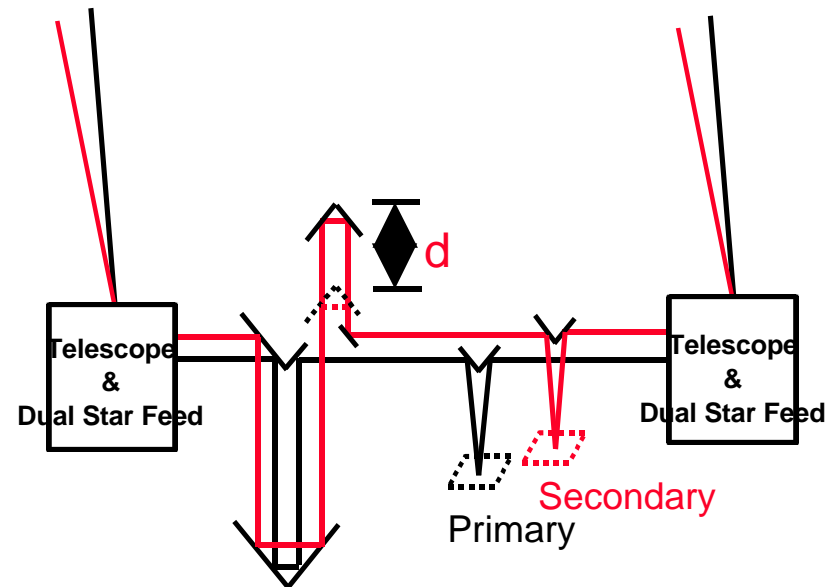


New in 1999 Season

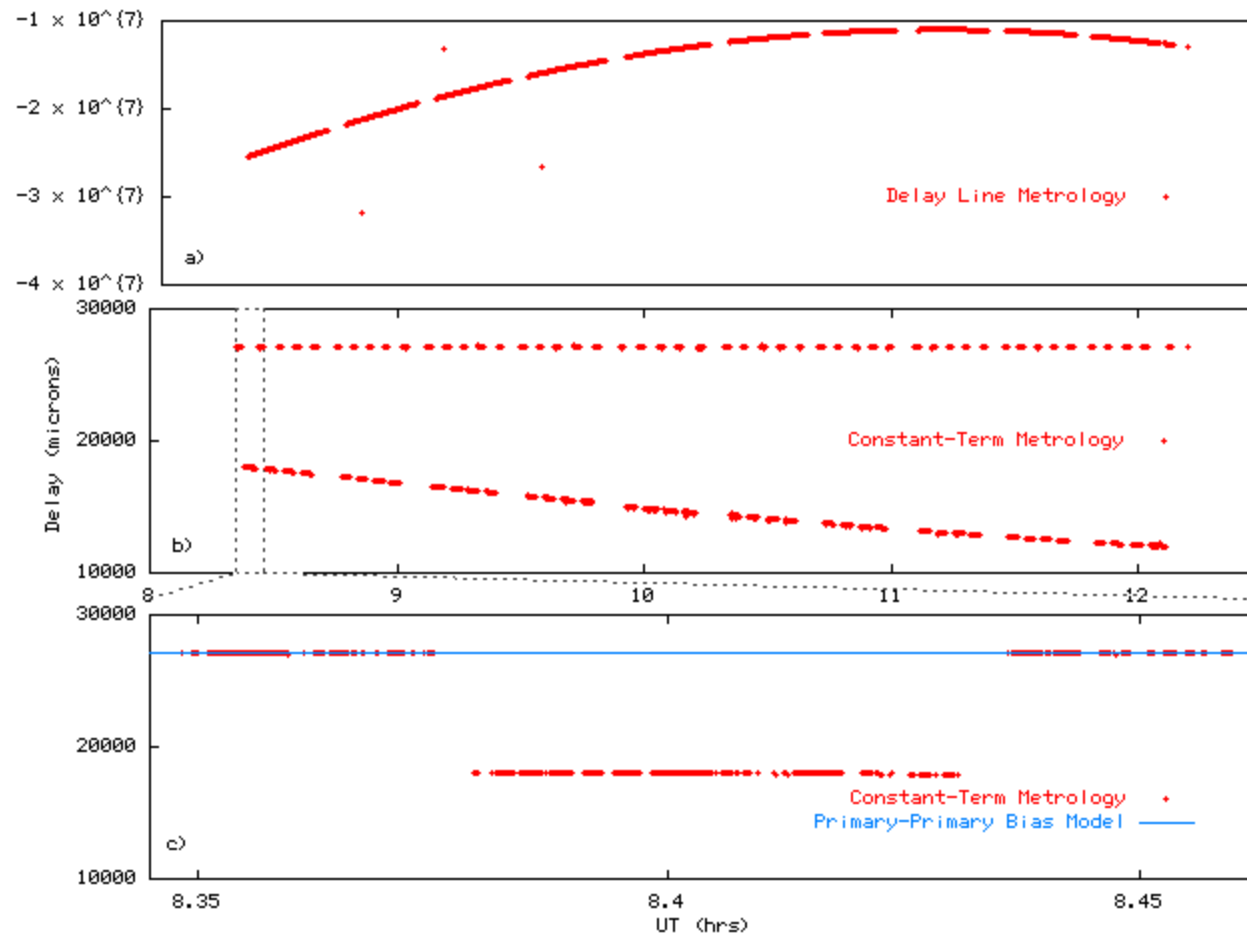
- Routine H-band capability
- Selectable coherent integration times
 - » 10, 20 ms for fringe tracking
 - » 50, 100, 250 ms for phase referenced
- Phase referencing with pathlength feedforward
- Narrow-angle baseline monitoring
- Automated pipeline reduction, archiving, reporting
- New observation planning tools

Narrow-angle astrometry with PTI

- With a long-baseline interferometer, accuracies < 100 μ as are possible with differential measurements over small fields
- Approach
 - Dual-star feed to separate out target star from astrometric reference
 - Dual beam combiners to allow simultaneous measurements
 - » One beam combiner tracks target star
 - » Second beam combiner switches between stars
 - Laser metrology to control systematic errors

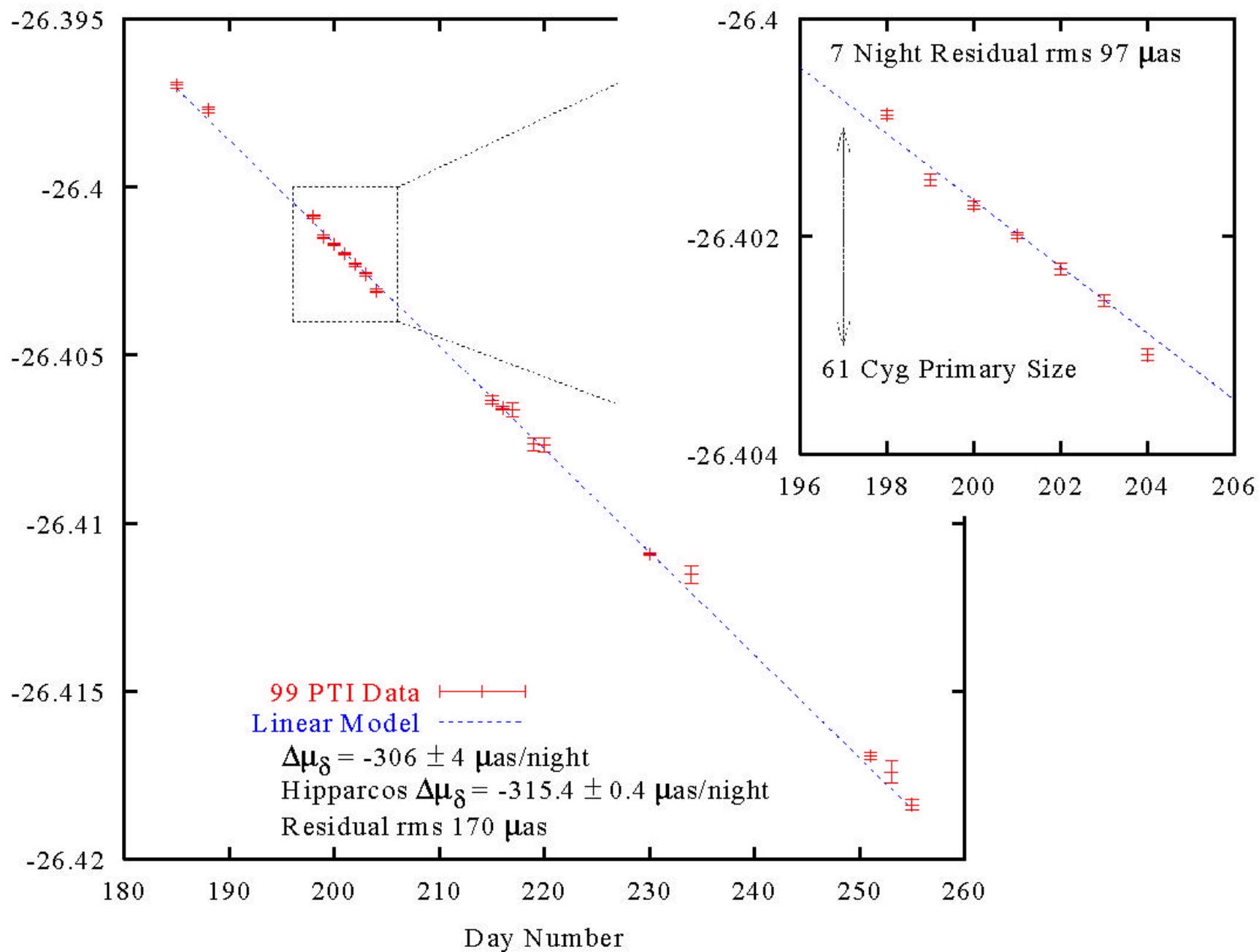


Narrow-Angle Astrometry



- We measure $\Delta d = B \cdot s + d$
- Baseline (B) is determined from wide-angle astrometry

61 Cyg Astrometry

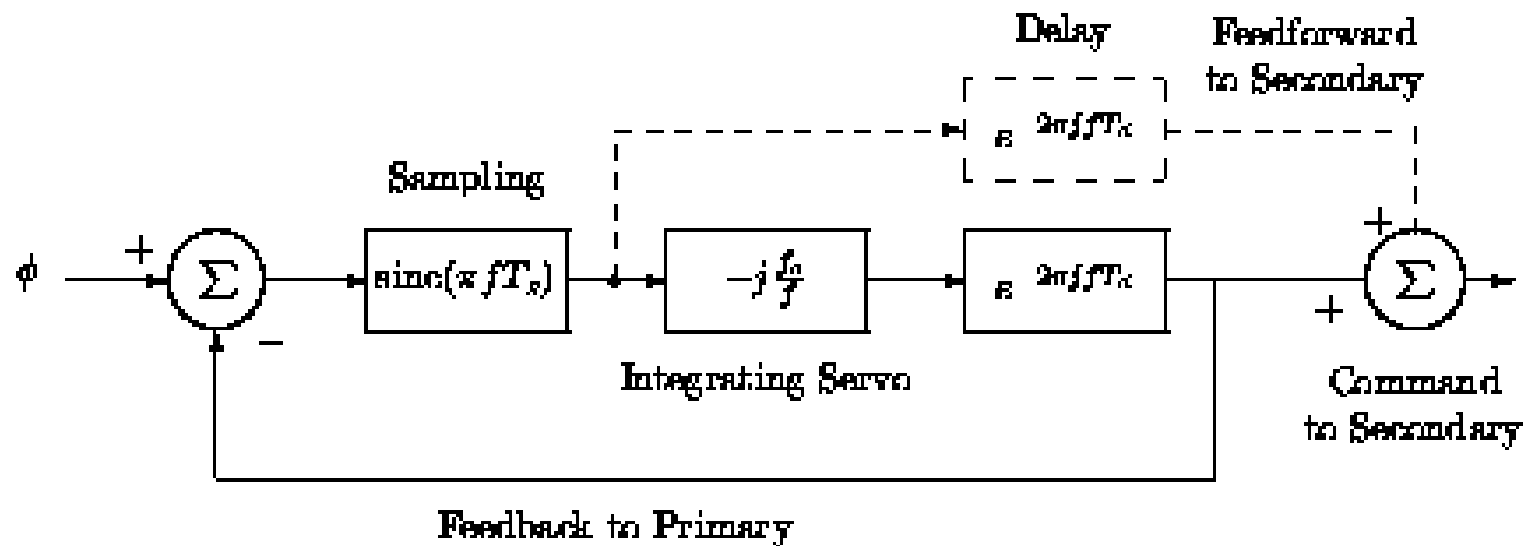




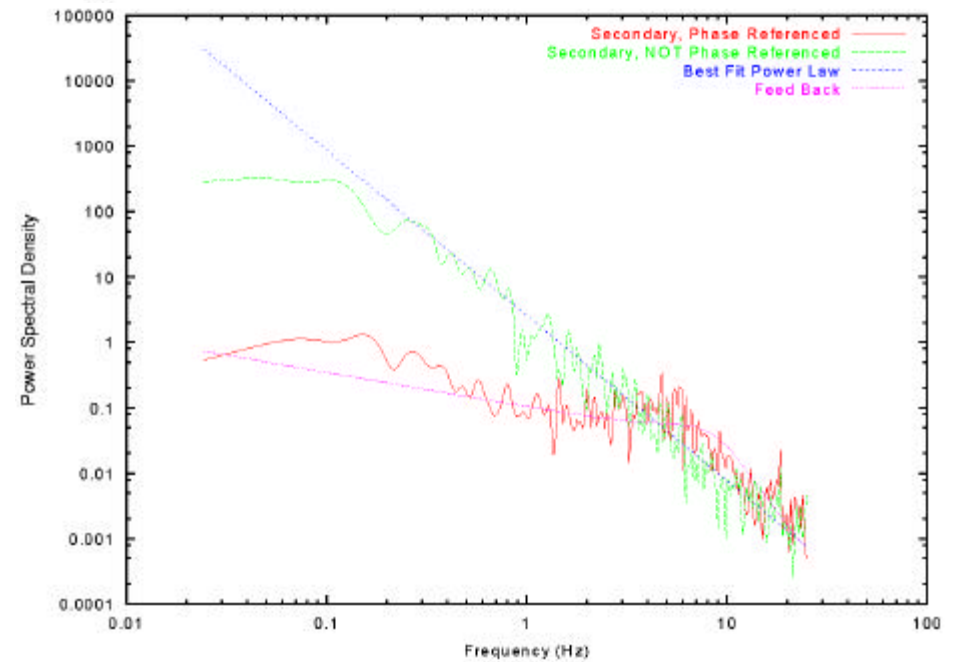
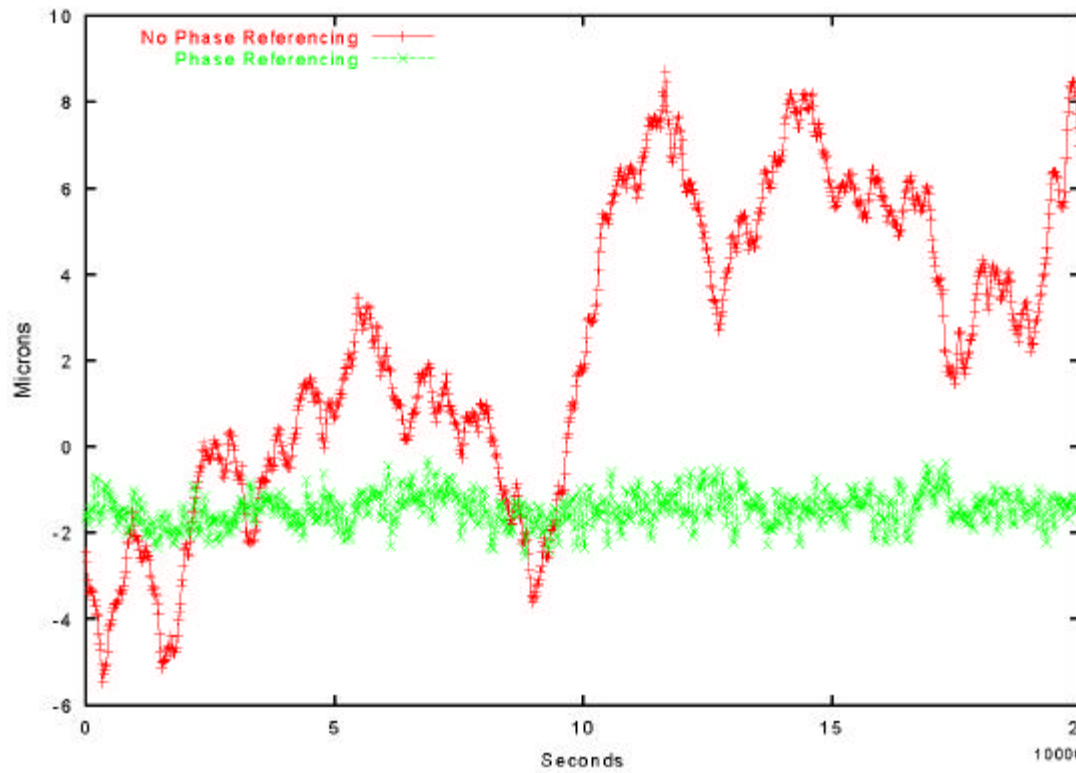
Phase Referencing with PTI

- Analogous to adaptive optics on a large telescope
- Approach
 - Fringe track on a bright star within the isoplanatic patch of the target star
 - Use as a probe of the atmospheric effects on the target star
 - Correct using optical delay lines by
 - » Feedback same signal to both stars' delay lines
 - » or... Feedforward signal to secondary star's delay line
- Advantage
 - Allows longer integration times that would ordinarily be possible
 - » Improved sensitivity

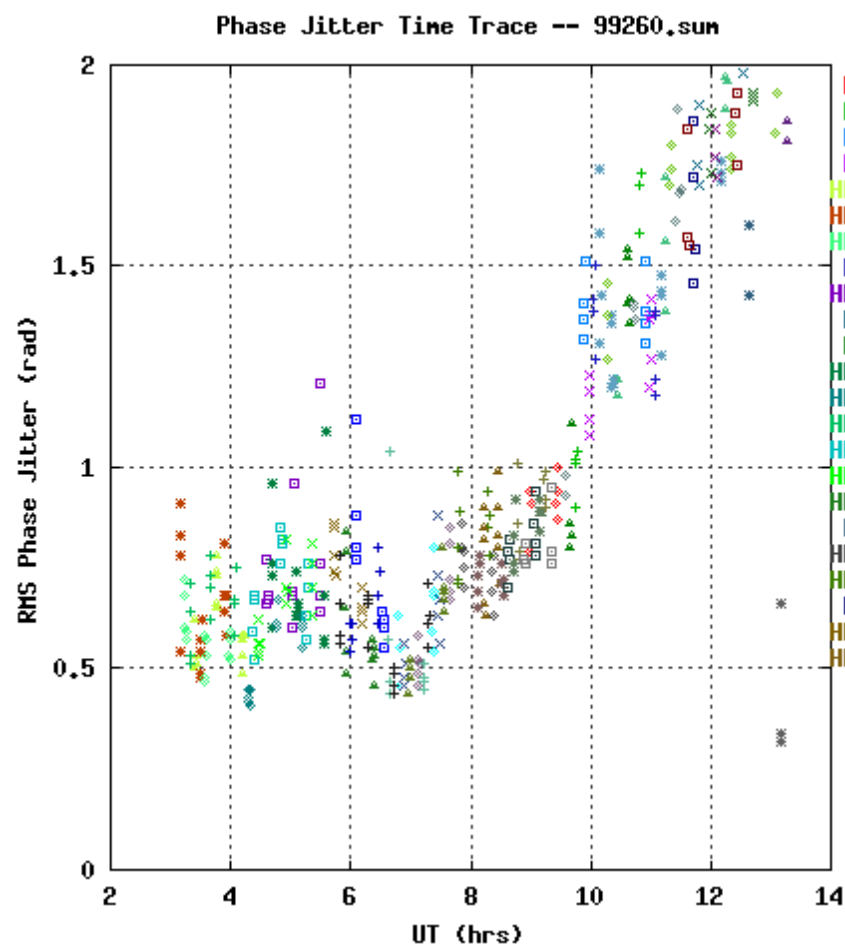
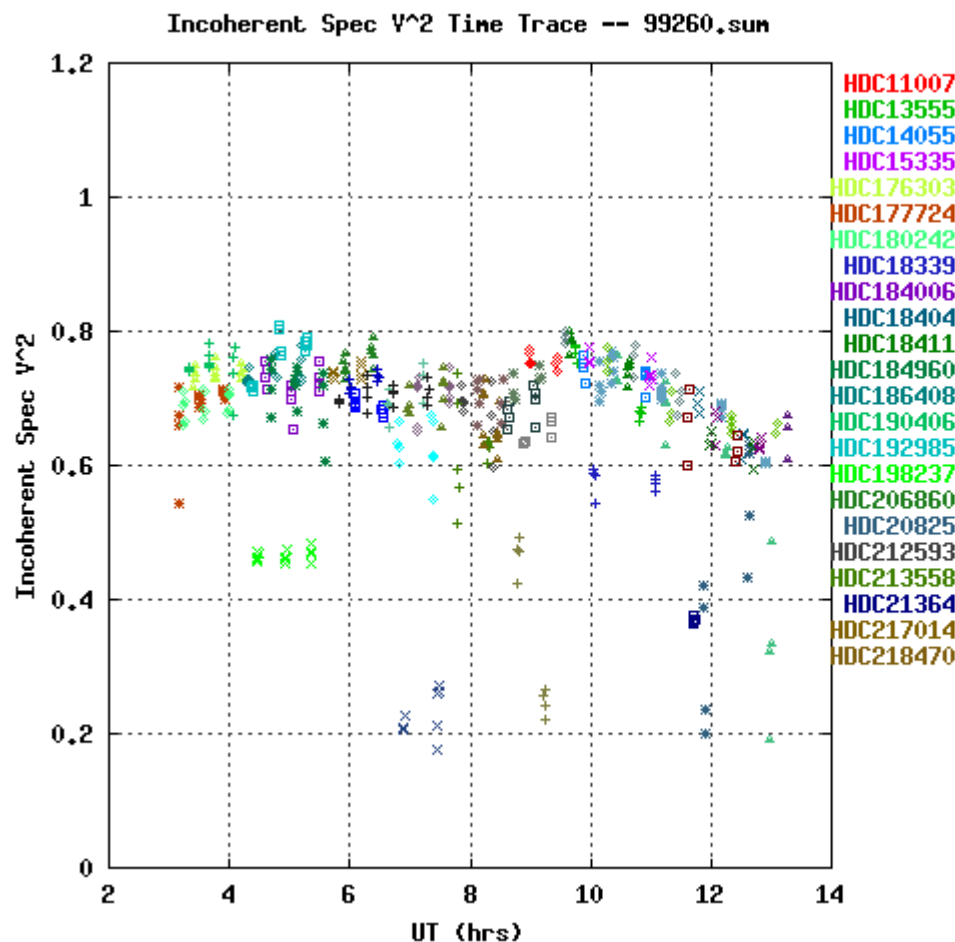
The Fringe Tracking Control Loop



Phase Referencing with PTI



Visibility and Seeing Data (25 sec points)



Automated Calibrator Selection

- Physical Parameter Estimation (Teff, diameter)
- Database query (Hipparcos, Simbad)
- Timing/Delay Range Calculations
- Real-Time Target Availability GUI

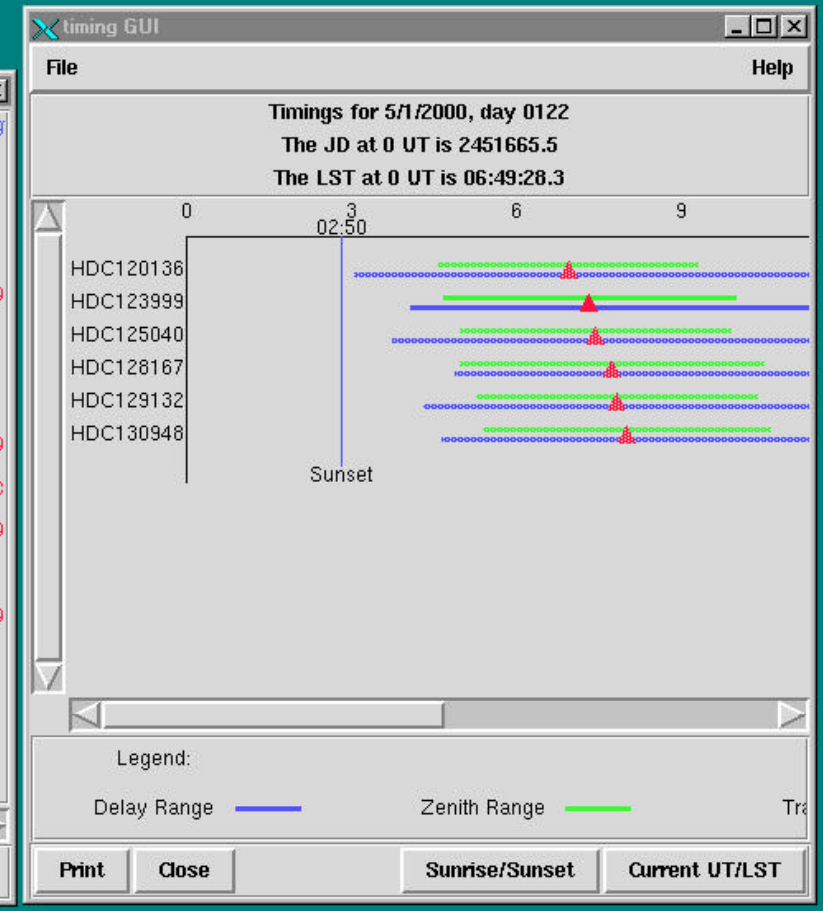
The 'getCal GUI' window displays configuration options for a target named '12_Boo'. The 'Object Designation/Pos' field is set to '12_Boo'. Under 'Calibrator Search Radius', 'Min V' and 'Max V' are set to 1. The 'Timing Info' section is active, showing 'Timing Display' and 'Select Date' set to May 1, 2000. Other options like 'fbol diameters', 'IR Data', 'Constrain Temp', 'fbol Plots', 'PostScript', 'EPS', 'Calibration Script Composition', 'Parallax', and 'xEphem Display' are also visible. Buttons for 'Dispatch', 'Reset', and 'Quit' are at the bottom.

```

getCal Return -- 12_Boo
/home/grid/pti/catalog/getCal.dev/getCal-2.2.1/getCal -targetName 12_Boo -lClass V -timing

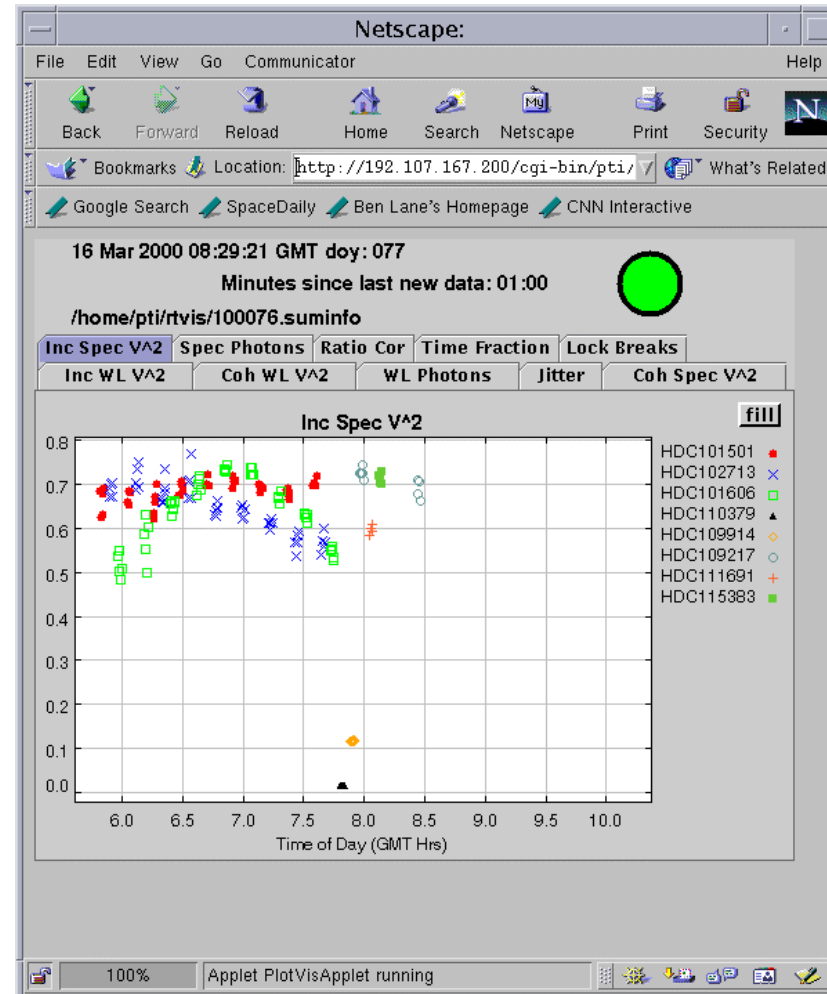
### GUI catalog from getCal v2.2.1dev ###
# Resolving target 12 Boo via SIMBAD
# target HD 123999
# Simbad Search HD 123999: Type: Spectroscopic binary F9IVw V=4.823
HDC123999 14 10 23.934 +25 05 30.037 -0.025 -0.060 4.8 4.8 F9IVw 0.0 xxx xxx trg
# Simbad Search HD 120136: Type: Variable Star F6IV V=4.50
HDC120136 13 47 15.743 +17 27 24.862 -0.504 0.054 4.5 3.2 F7V 9.3 0.79+/-0.2 cal HDC1239
# HIP 69751 (HD 125040) has his multiple component flag set to C
# the C designation indicates solutions were found for individual components
# 2 components:
# A component -- V= 6.506
# B component -- V= 8.657 at sep 4.425 arcsec/PA 157 deg
# Simbad Search HD 125040: Type: Star in double system F8V V=6.25
HDC125040 14 16 32.843 +20 07 18.654 -0.145 -0.094 6.2 4.9 F8V 5.2 0.37+/-0.1 cal HDC1239
# Simbad Search HD 128167: Type: Variable Star F2V V=4.46
HDC128167 14 34 40.817 +29 44 42.468 0.217 0.133 4.5 3.6 F3Vvvar 7.1 0.78+/-0.0 cal HDC
# Simbad Search HD 129132: Type: Spectroscopic binary G0V V=6.137
HDC129132 14 40 21.874 +21 58 33.125 -0.016 0.040 6.1 4.7 G0V 7.5 0.29+/-0.4 cal HDC1239
# HIP 72567 (HD 130948) has his variability flag set (1)
# with 0.011 mag scatter in 148 observations
# Simbad Search HD 130948: Type: Star G1V V=5.880
HDC130948 14 50 15.811 +23 54 42.639 0.158 0.032 5.9 4.4 G2V 9.1 0.54+/-0.0 cal HDC1239

# Timing summary run at 1/4/100, day 10004
# for timings on 5/1/2000, day 0122
# The JD at 0 hr UT is 2451665.5
# The LST at 0 hr UT is 06:49:28.3
# Approximate UT sunset -- sunrise times: 02:50:55 -- 12:38:11
# Using 35 deg zenith angle constraint
  
```



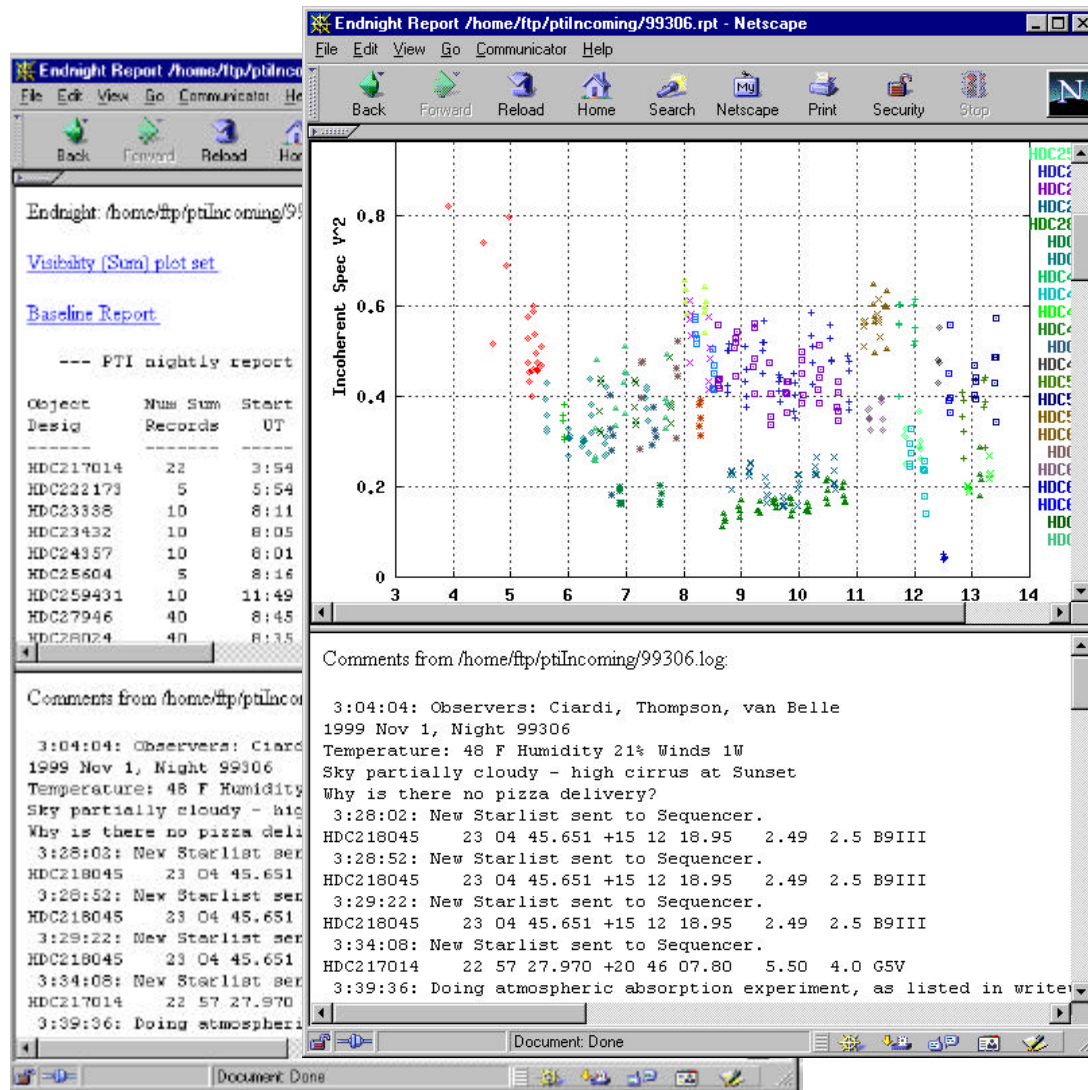
Quick-Look Data Processing

- Real-time data processing
 - Visibility
 - Fringe Jitter
 - Intensities, Ratio
- WWW/Java interface
 - Access from anywhere



Automated Level-1 reductions

- Scripts automate end-of-night reductions
 - Level -1 reductions
 - » Calibrated visibilities
 - » 25 sec visibility points
 - Baseline model
 - Email report to collaborators
 - Web access to nightly summary, log
 - CD burns of level-0 data





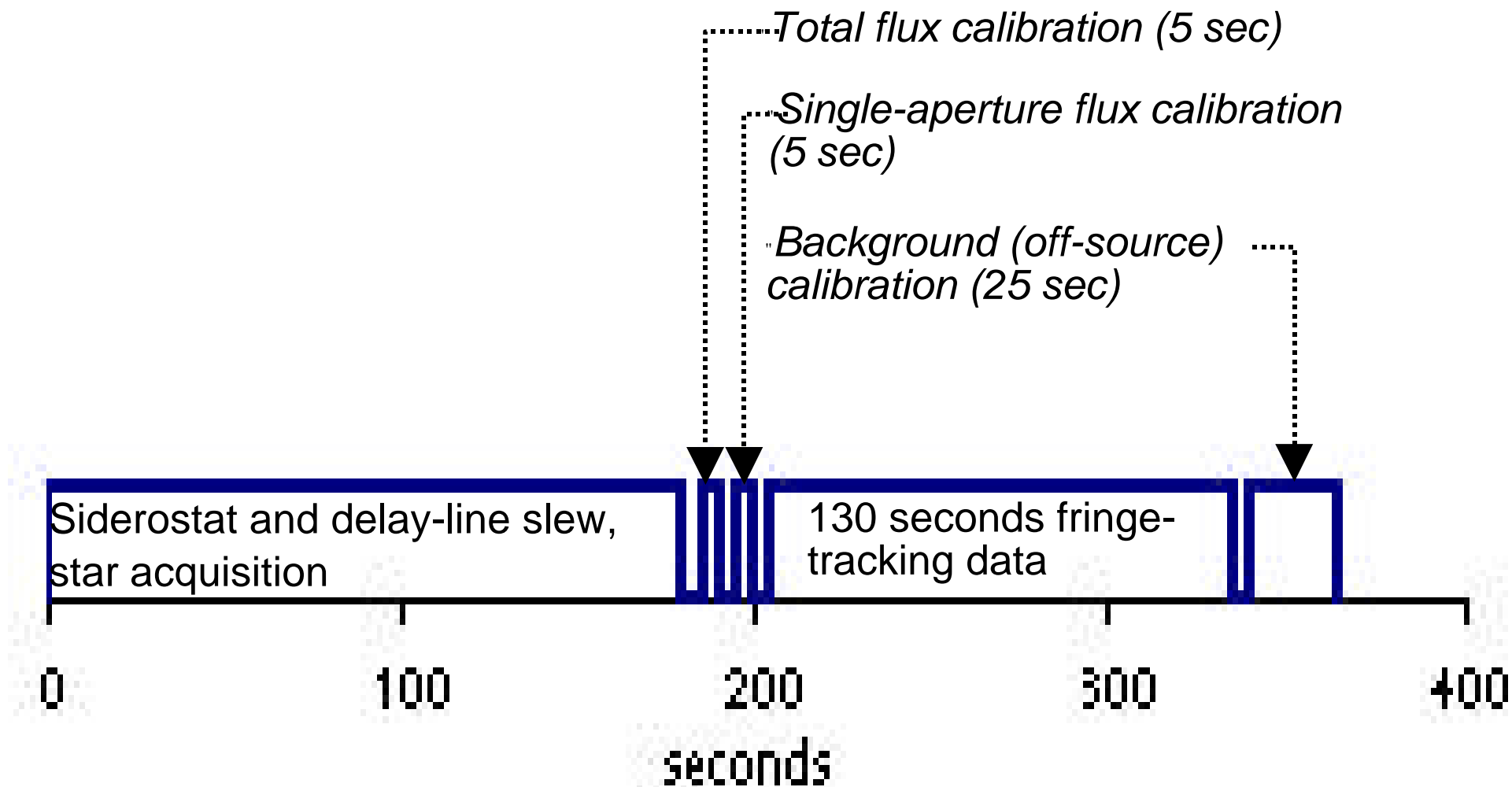
New for 2000 Season

- Low-Background Dewar
- HAWAII Detector
 - » Improved read noise
 - » Improved spectrometer resolution ($R \sim 100$)
 - » Improved Tracking Limit ($mK > 6$)
- Operational North-West Baseline
 - » Extended Sky Coverage
 - » 2D astrometry
- Improved Siderostat Pointing
 - » Increase Observing Efficiency



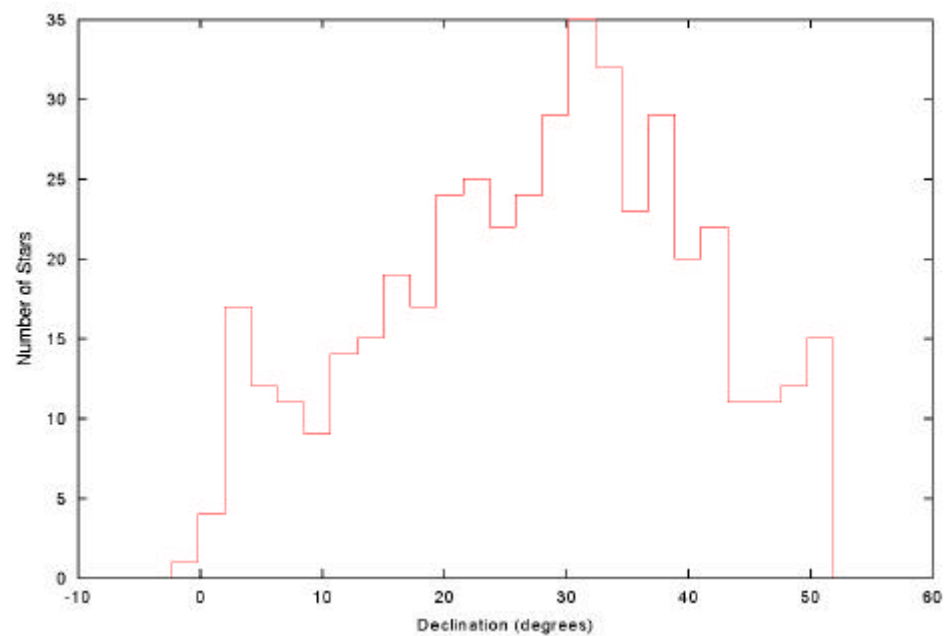
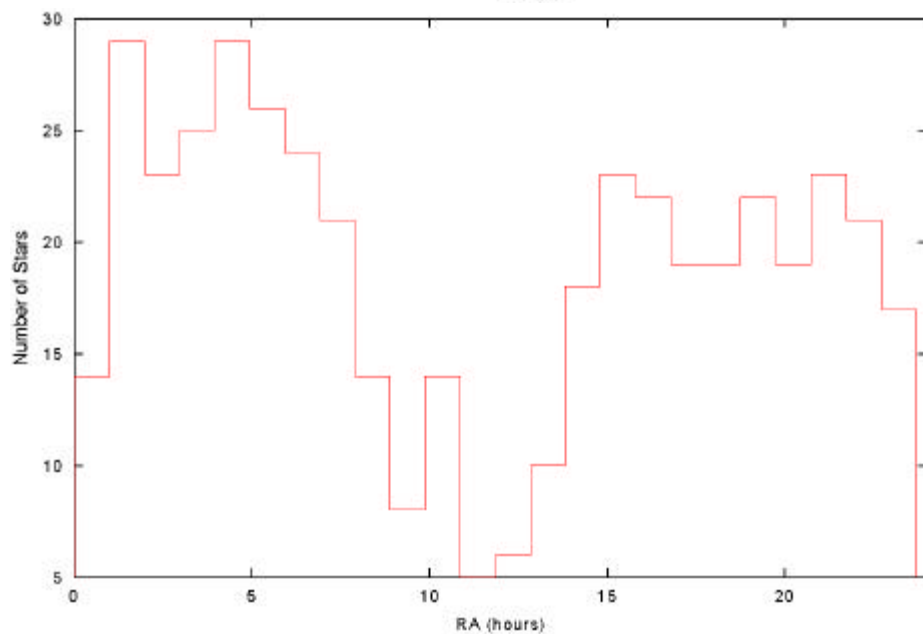
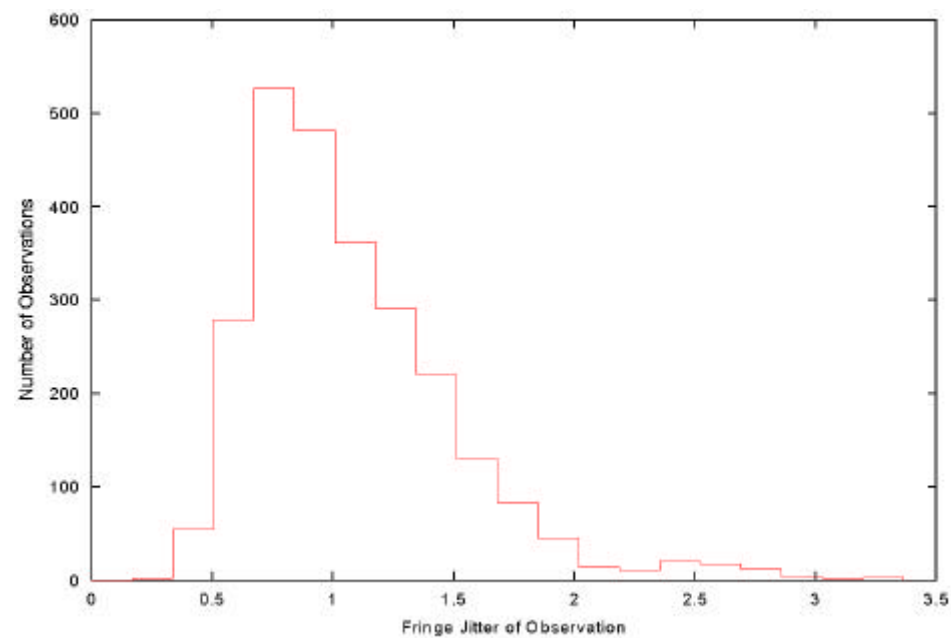
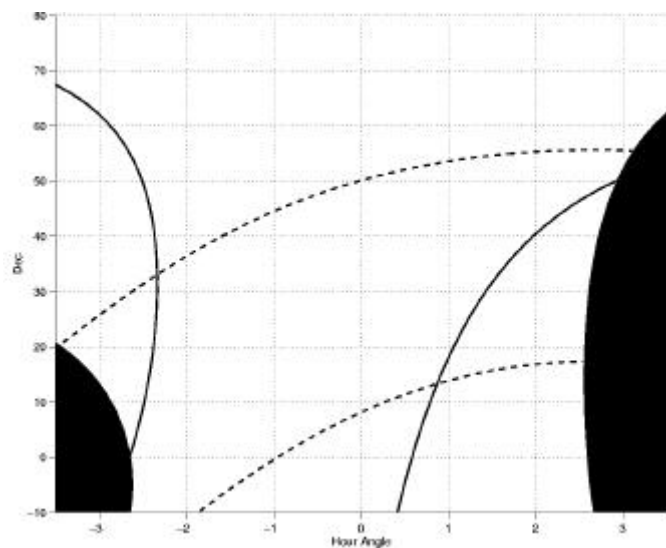
Backup

A "Scan"

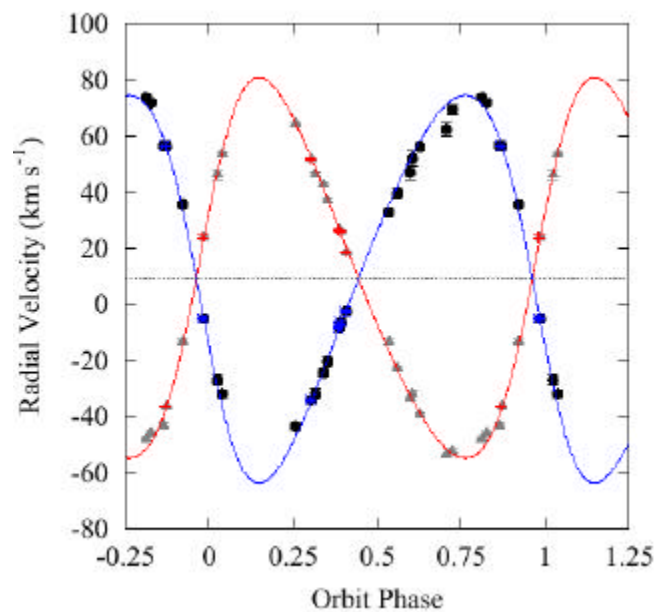
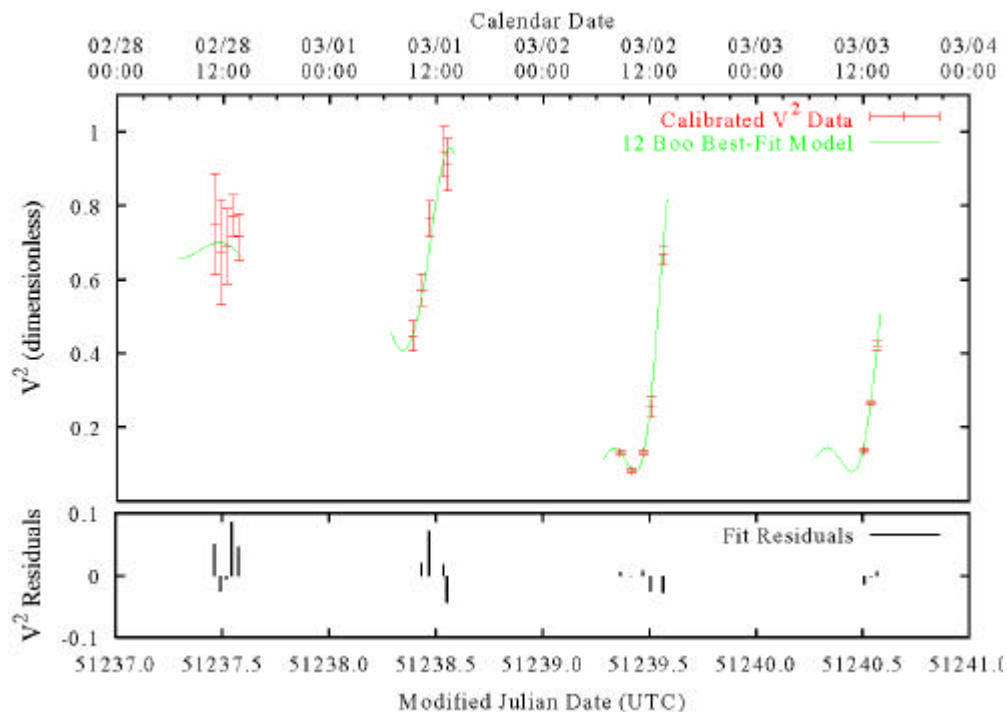
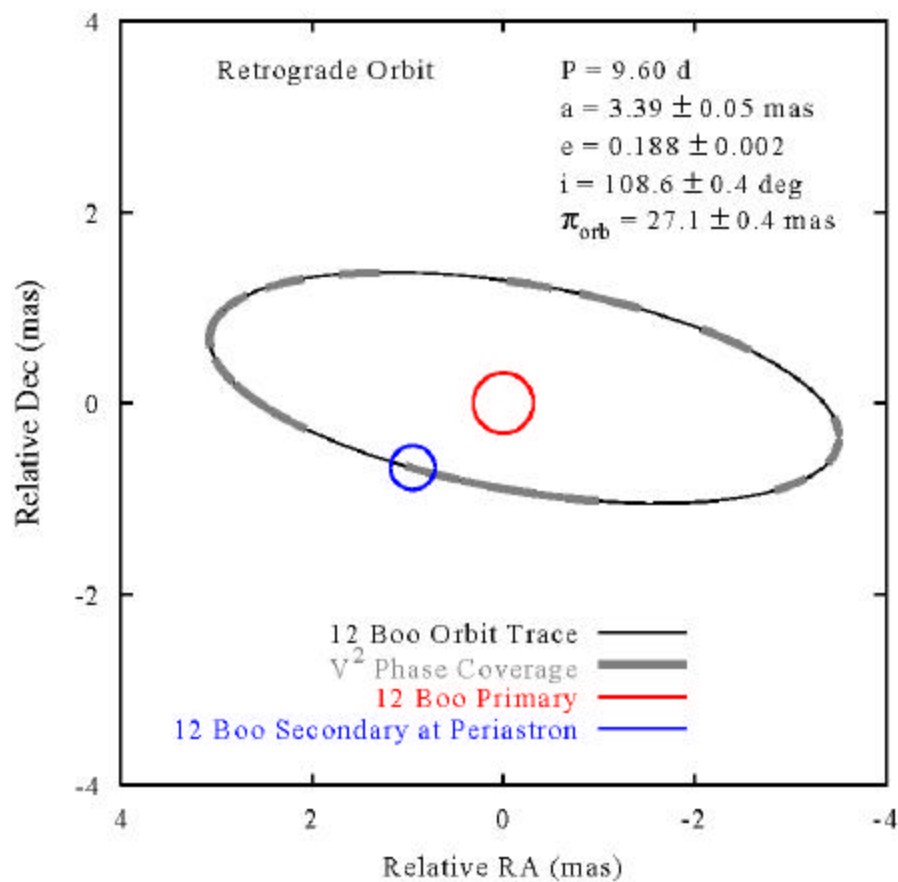




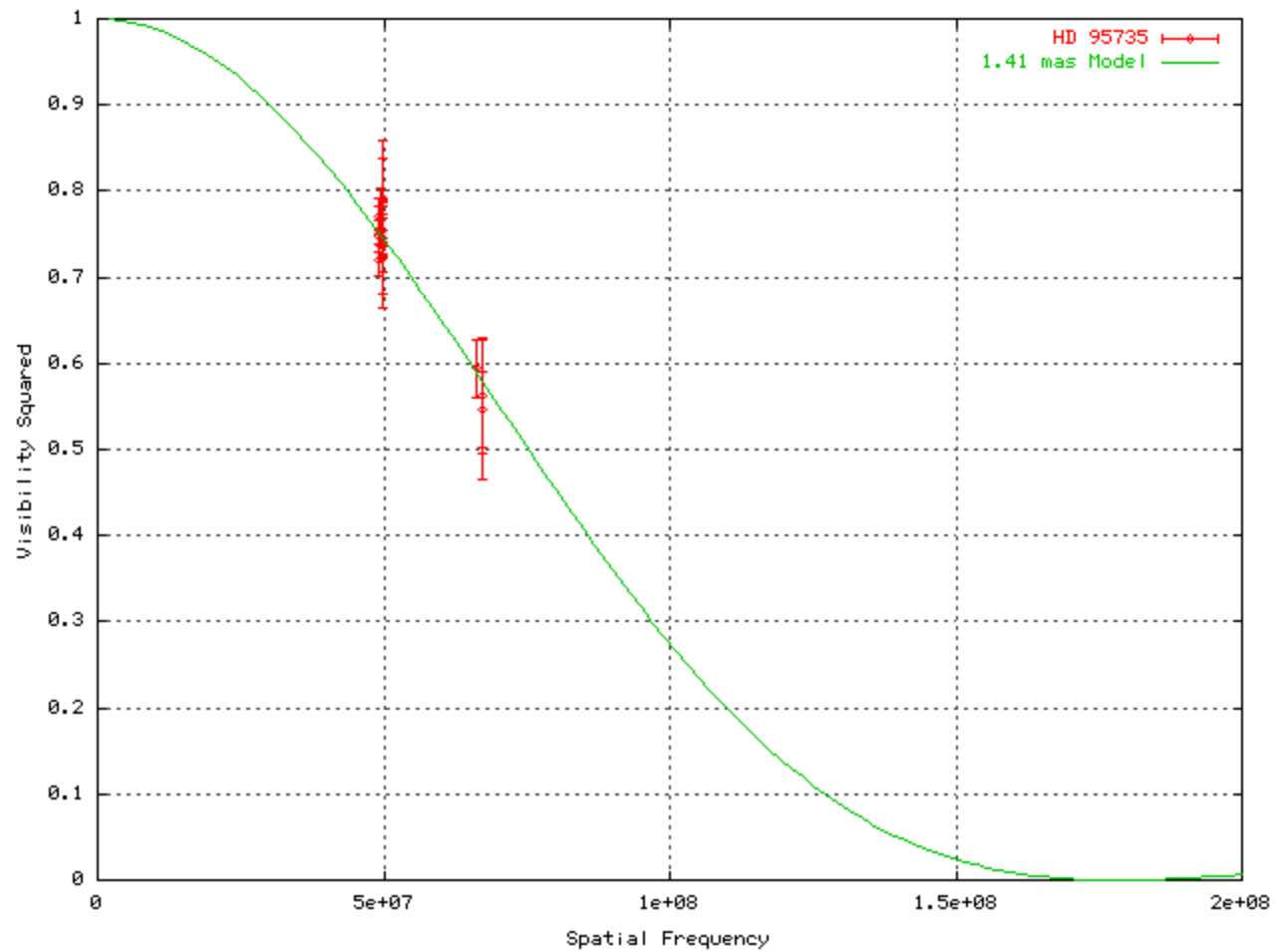
More Observing Stats



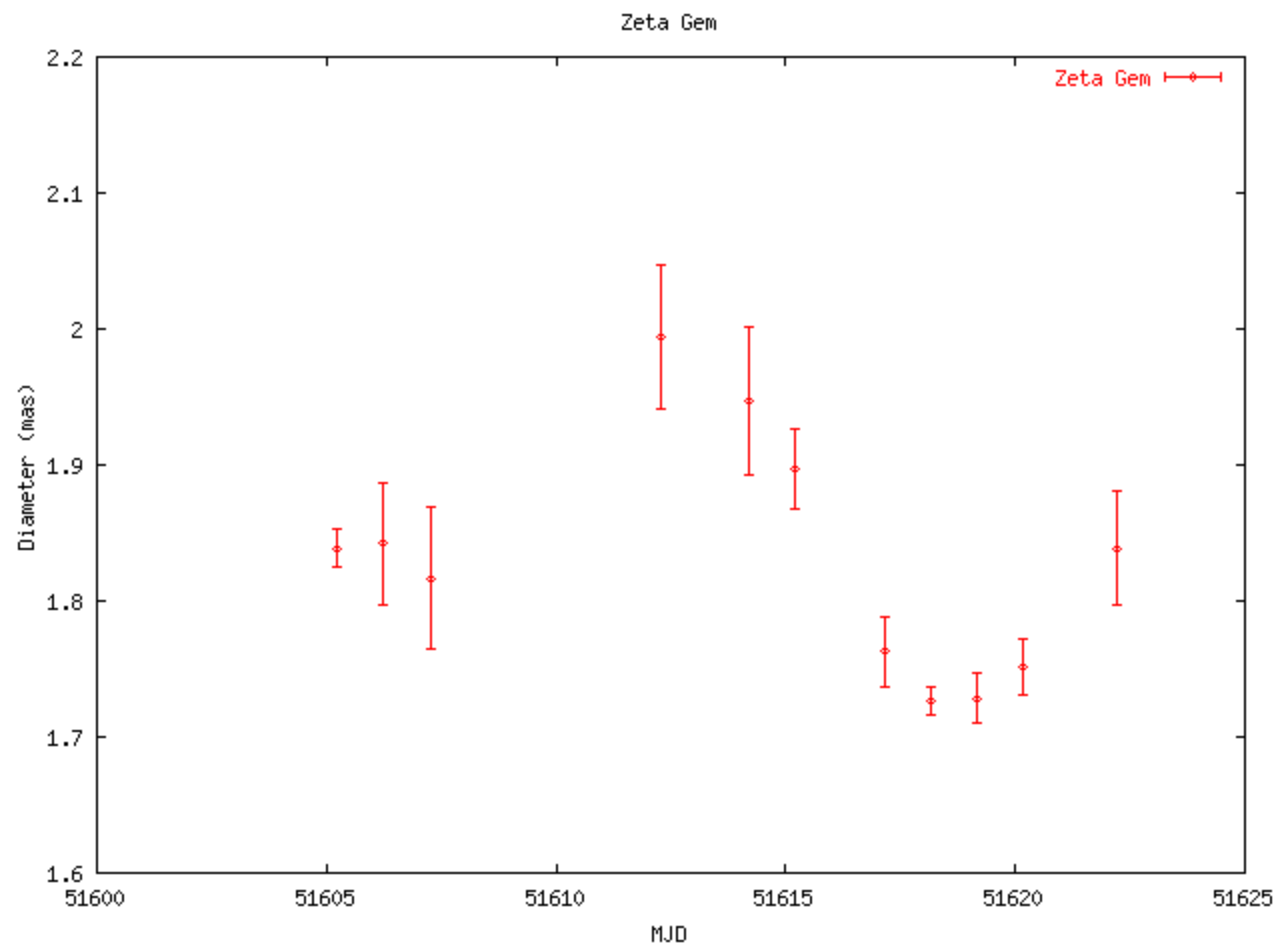
12 Boo Analysis

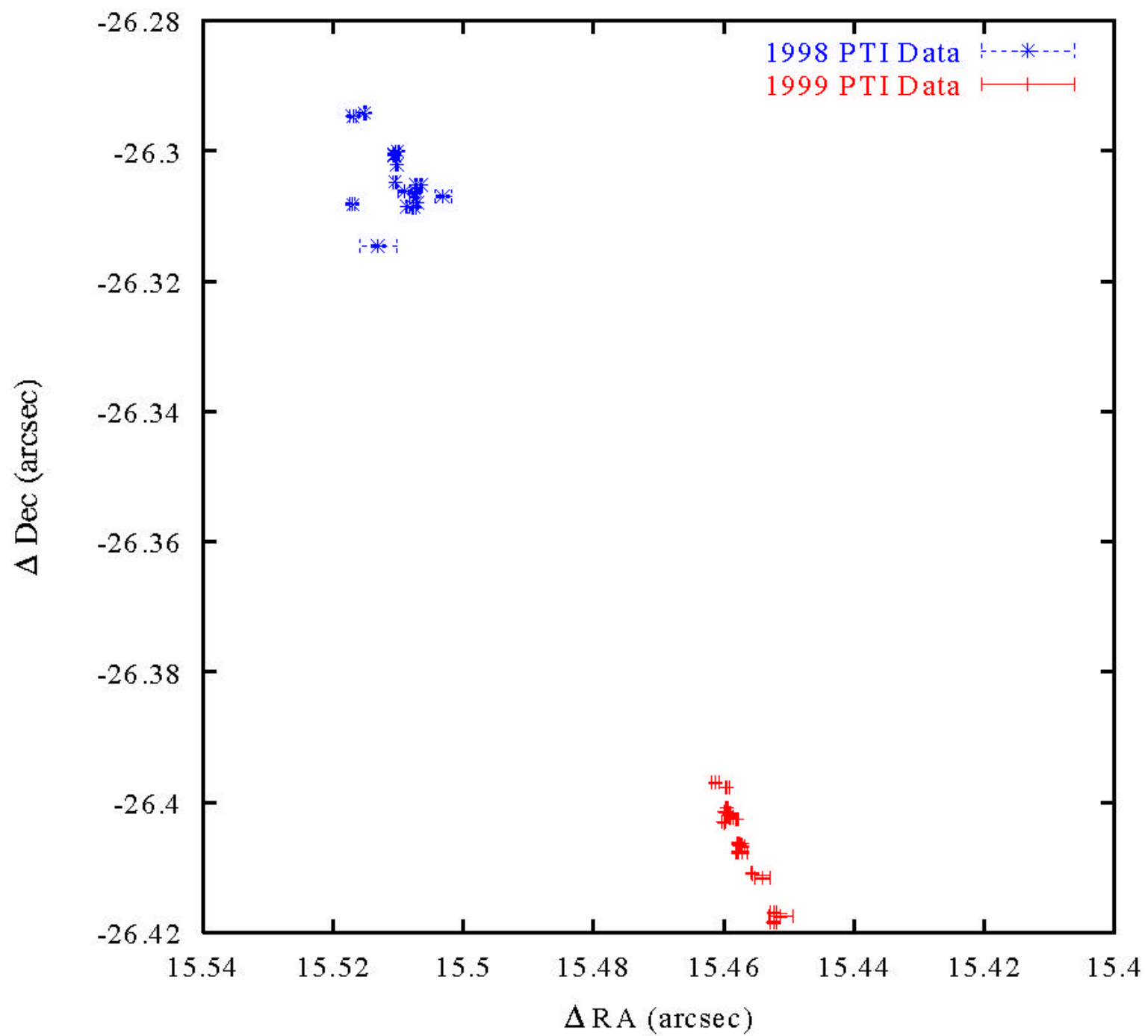


Measuring Diameters



Z Gem





61 Cyg Astrometry

